TRRP Silviculture Specialist Report
Western Divide Ranger District

PREPARED BY: George Powell DATE: April 21, 2014

GEORGE POWELL
Certified Silviculturist

Relevant Laws, Regulations, and Policy

The proposed action and alternatives follow the legislative authorities for administration of the National Forest System vegetation and fuels management programs; which are listed in Forest Service Manuals 2020 and 5150, respectively (USDA 2013 and USDA 1991). Objectives, policies, and responsibilities for ecological restoration and fuels management are in FSM 2020 and FSM 5150, respectively.

The objective for vegetation is to "reestablish and retain ecological resilience of National Forest System lands and associated resources to achieve sustainable management and provide a broad range of ecosystem services." (FSM 2020)

The objective for fuel management is "to identify, develop, and maintain fuel profiles that contribute to the most cost-efficient fire protection and use program in support of land and resource management direction in the forest plan." (FSM 5150)

The vegetation desired condition is defined in the Giant Sequoia National Monument Management Plan. "Forested stands in the Mediterranean climate of the Monument are subject to frequent weather cycles. Years of cooler, wetter weather are often followed by years of hotter, drier weather. The desired condition of a forested stand subject to these extremes is diversity in composition (species, size, age class, distribution) and spatial distribution that are expected to be more resilient to climate changes over time (USDA Forest Service 2012)."

Analysis questions from scoping respondents

<u>What is the canopy structure in the units proposed for entry? Describe the canopy structure post-project.</u>

<u>What changes do you anticipate to microclimate, vegetation, wildlife movement, and soils from this project?</u>

<u>What is the Potential Natural Vegetation (PNV) within the analysis area?</u>

<u>CFA believes that your purpose and need for the project should be to create a vegetative desired condition that will lead to a healthy forest resistant to insects, disease and wildfire. Simply "reducing surface and ladder fuels" may fall short of the desired condition.</u>

<u>The proposed action calls for spacing trees to an average of 25 feet apart. We suspect that would move the landscape toward a desired condition. However, the proposed action establishes a diameter limit ("do not cut trees over 12 inches dbh"), which likely would not support moving toward a desired condition. Further, if there are merchantable trees that need to be removed to meet a 25'spacing, those trees may have value that could contribute to defraying some of the overall cost of the project.</u>

Methodology and Analysis Process

I used modeling with the Forest Vegetation Simulator (FVS) to model the effects of no action, the proposed action, and alternative 3. I based the modeling on the California wildlife habitat relationship (CWHR) cover types (Mayer and Laudenslayer 1988). I modeled the planted stands separately. I modeled everything with and without a wildfire. Stand exam data and Forest Vegetation Simulator modeling (Dixon 2010) are on file at the Western Divide Ranger District. The results of this modeling are on file at the Western Divide Ranger District.

Existing Conditions

The TRRP project area includes 1,700 acres of the Black Mountain Grove, and 1,140 acres outside the grove. Existing conditions are based on stand exam data, the Black Mountain Giant Sequoia Grove Inventory (Grove Inventory) (Jump 2004), and FVS modeling. Overall the project area is composed of overstocked stands with virtually no regeneration of shade intolerant species outside some areas of planted trees (Jump 2004, Meyer and Stafford 2011).

The Black Mountain Giant Sequoia Grove spans portions of the Tule River Indian Reservation and the Monument. The majority of the grove, approximately 2,615 acres, is within the Monument and part of the Sequoia National Forest. The remaining 205 acres are in the Tule River Indian Reservation and on private property inholdings in the Monument.

According to the Grove Inventory Black Mountain Grove has a complicated land ownership history. From an early date, large areas of the grove were privately owned, or were included in the Tule River Indian Reservation. Some of this land was heavily logged for giant sequoias and other timber, while much of it remained pristine until 1960. Most of the grove in the Monument escaped significant pre-1950 logging. Meyer (1952) reported that almost all of the then Sequoia National Forest grove land still had little or no logging. Some areas in this part of the grove were partially cut in the 1950s. The 1964 to 1965 Solo Peak Timber Sale selectively harvested an unknown volume of non-sequoia conifers, by individual tree selection methods, on 116 acres. The early 1970s Black Mountain Sale focused on the western side of the grove.

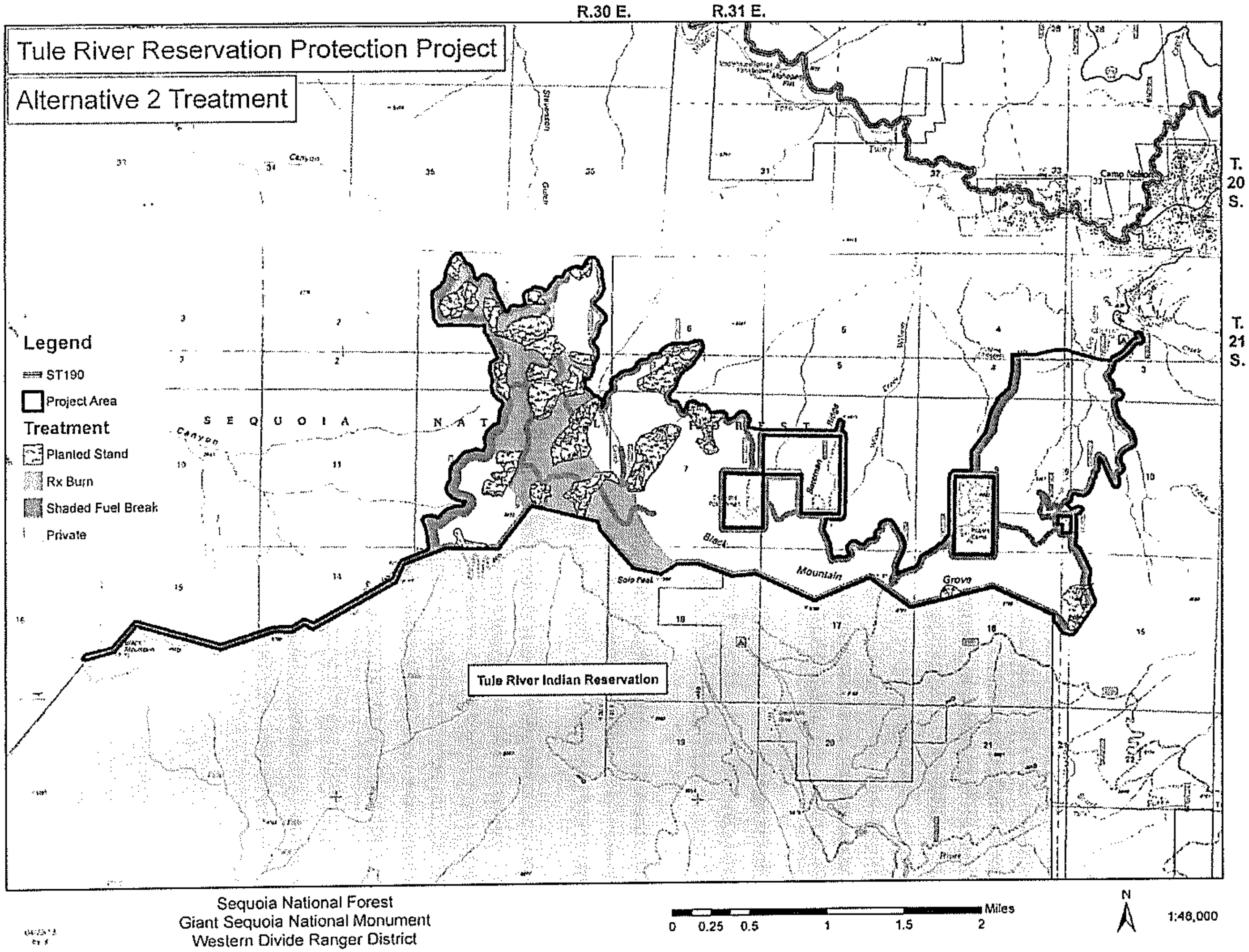
Some of the grove was cut over before the Sequoia National Forest acquired it from private landowners in the 1975 Crawford Exchange. That area included land adjacent to Rogers Camp, as well as 120 acres near the Simmons Post Camp site.

As shown in Figure 1, there are an estimated 400 acres of planted trees in the project area. Outside the grove, approximately 142 acres were planted in the 1970s. These areas were planted with a mix of species, including sequoias both inside and outside the grove.

In the grove, approximately 12 unstocked acres were planted in 1964. In 1965, another 40 acres were planted. The Solo Sale and the Gauntlet Sale were implemented in the 1980s, mostly in the western part of the grove, to improve sequoia regeneration. These projects created 11 plantations covering approximately 206 acres in the grove. Non-sequoia "whitewoods" were harvested with the objective of obtaining giant sequoia regeneration, which was not happening naturally because of the dense, crowded stands and closed canopy (Figure 2). All large giant sequoia trees were protected during these harvests.

Currently sequoias make up almost 18 percent of the trees in the planted stands in Black Mountain Grove, and almost 9 percent of the trees in planted stands in the TRRP project area outside the grove.

Figure 1: Alternative 2 Treatment Areas



Outside of the planted stands, the species composition and structure in the TRRP project area is generally consistent both inside and outside the sequoia grove. As discussed in the Grove Inventory, there is a relatively broad representation of tree age classes, with most trees between 10 and 34 inches dbh, and between 70 and 150 years old. Most of the larger giant sequoia were 43 to 161 inches dbh, and too large to bore to determine age. Five sequoias between 23 and 41 inches dbh and averaging 152 feet tall, were bored and found to average 131 years old. In 2004 most of the overstory trees in the grove were between 100 and 200 years old, and the conifer and black oak canopy cover averaged 75 percent closed. The dense canopy cover favors shade-tolerant species such as white fir, and there is a lack of sequoia, ponderosa and sugar pine seedlings in these areas (Jump 2004). As shown in Table 1, giant sequoia trees average only 4 percent of the trees per acre, which is significantly below the desired number of sequoias (10 percent of trees per acre) needed to sustain the stand.

Table 1: Trees and Seedlings per Acre by Species in Black Mountain Grove outside planted stands[a]

Tree Species	Percent of Trees/ Acre	Number of Seedlings/ Acre	Percent of Basal Area/ Acre
Giant sequoia	4	0	20
Ponderosa pine	4	10	1
Sugar pine	12	20	17
White fir	52	151	47
Incense cedar	17	55	10
Black oak	Not shown	31	Not shown
Nutmeg	Not shown	6	Not shown
Pacific dogwood	Not shown	55	Not shown
TOTAL	**89**	**328**	95

[a] From Jump 2004: Table 1. Species Composition, and Table 3. Seedlings per acre.

In the planted stands, most of the largest sequoias are located in groups. Most of the sequoia regeneration is where the treatments in the 1970s and 1980s created openings with bare mineral soil for these trees to provide seed for a new generation of sequoias. The 11 planted stands are the only areas in the grove with noticeable sequoia regeneration occurring at this time. Many of the planted and naturally occurring sequoia seedlings in these areas are over 20 feet tall.

Though the variety of species expected in a mixed conifer forest is present in the grove, the basal area reflects the years of fire suppression (Table 1). According to Jump (2004) sequoia represent 20 percent of average basal area per acre, which is about half the recommended amount in the inventory, and shows the unnaturally high amounts of shade-tolerant conifer species resulting from decades of fire suppression. In contrast, white fir is almost triple the basal area recommended for mixed conifer stands where fire has not been suppressed for so long.

There is a lack of large sugar pines, in part because some have died in the past two decades. This dieback is due to lack of available soil moisture resulting from competition with the numerous white fir and other more shade-tolerant species (Jump 2004).

Another indicator of fire suppression, and that the grove is relatively young, is that 96 percent of the trees are mixed conifer with a large component of white fir (shade tolerant species), and the basal area is 80 percent mixed conifer as well, which is considered high in terms of natural variability. In a more mature grove that has had more frequent fires, these numbers would closer to 90 percent of trees in mixed conifer, and 35 percent of the basal area. Larger sequoias, though few in number, would represent the majority of the basal area due to their large size and volume (Jump, 2004).

As shown in Table 2, in 2004 the average basal area in the inventoried portion of the grove was 392 square feet per acre, of which 71 square feet per acre was in scattered sequoias that were generally larger than 40 inches dbh. As shown in Table 1, no sequoia seedlings were found during inventories. White fir 15 inches dbh or larger in size, account for 165 square feet of the basal area per acre. This level of stand density is much too high for maintenance of reasonable tree growth and vigor.

Table 2: Trees and Basal Area per Acre by Diameter Class in Black Mountain Grove [b]

Diameter Class (inches at dbh)	Basal Area per Acre (square feet)	Trees per Acre
1-4	6	133
5-10	39	90
11-14	31	31
15-20	52	38
21-28	64	30
29-38	58	20
39+	142	14
TOTAL	**392**	**356**

[b] From Jump 2004: Table 2. Grove Density and Tree Stocking by Diameter Class (conifers)

Evidence of density-related mortality is documented in the Grove Inventory datasheets. Fourteen of the 51 inventory plots had five or more snags and average 35 snags per acre in the grove. Most of the snags are white fir and sugar pine understory trees less than 20 inches dbh, which contribute to ladder fuels. As shown in Table 3, the majority of the snags are also in the suppressed category, which increases the likelihood of contributing to fuel ladders in the event of a fire.

Table 3: Snags per Acre by Crown Position in Black Mountain Grove Inventory [c]

Crown Position	Conifer	Hardwood	Total Snags by Crown Position
Dominant	3.3	0.16	3.46
Codominant	2.51	0.16	2.67
Intermediate	5.02	0.86	5.88
Suppressed	17.18	5.75	22.93
Total Snags by Type	28.01	6.93	34.94

[c] From Jump 2004: Table 7. Snags per Acre by Crown Position

Seventeen of the 51 inventory plots had six or more down logs on the 1/8 acres plot. Down logs, mostly 24 inches and larger in diameter, average 39 per acre and account for 44 tons per acre of the total fuel loading according to inventory data. A portion of the standing snags inventoried in 2004 are likely to have fallen, and have added to the surface fuel loading.

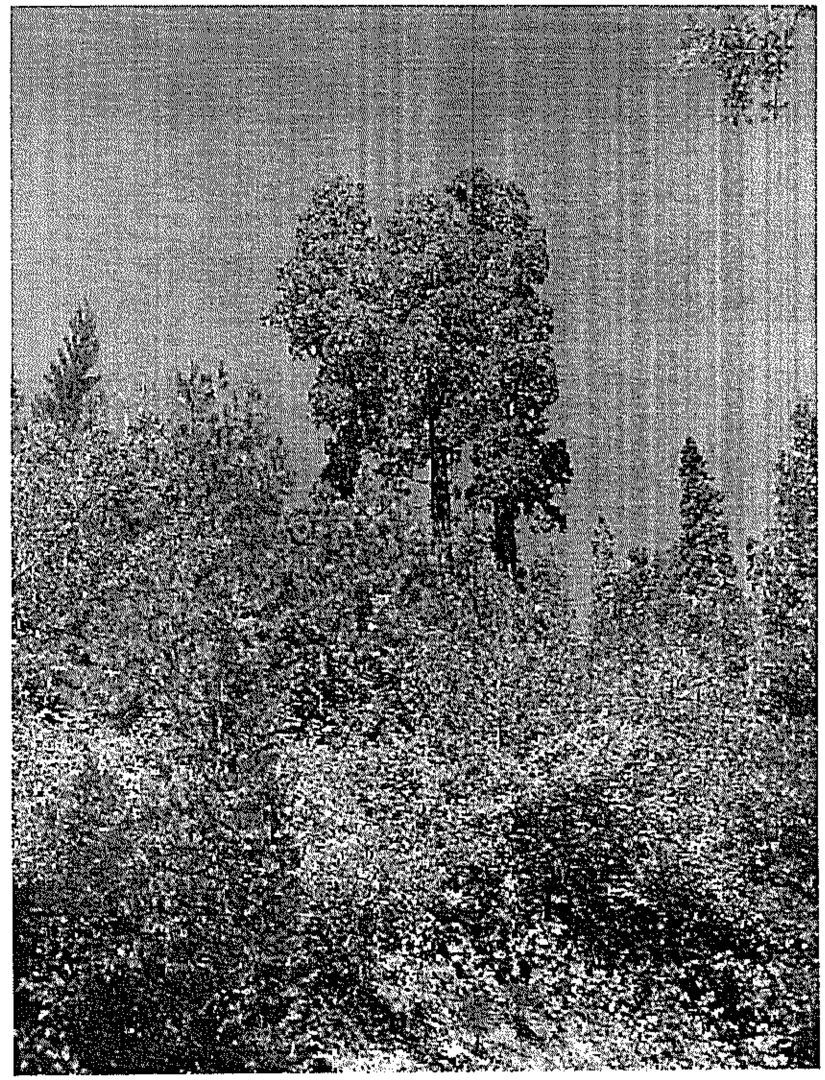
Overall, the inventory of the Black Mountain Grove shows that the grove has many of the fire susceptibility problems associated with departure from the historic fire return interval as indicated by the large number of snags and down logs in the grove (Jump 2004). Based on Tables 1, 2 and, 3 giant sequoia regeneration is lacking overall, and shade-tolerant species (especially white fir) have increased. Trees less than 12 inches dbh are the predominate number of trees per acre in much of the grove and, due to being suppressed and dying, make up the ladder fuels that lower the canopy base height in wildfire situations.

The forest stand conditions are the same in the areas proposed for treatment outside the grove, based on the stand exam data used in the FVS model. The term "Potential Natural Vegetation" refers to an expected state of mature vegetation in the absence of human intervention. This is analogous to the "Climax Plant Community" plant succession model (Henderson et al. 2011). The PNV on the best growing sites would be giant sequoia dominated mixed conifer, on good sites fir dominated mixed conifer and on poor growing sites montane hardwood conifer mix or mixed montane chaparral (North et al. 2009). Based on the stand exams and inventories, portions of the project area are at the climax plant community successional stage, which is not a stable state, especially considering the predicted changes in climate.

Fire suppression has altered the fire return interval in the project area. The accumulation of woody debris has led to an unnaturally high level of surface fuels in the majority of the grove and surrounding forest, which impedes establishment and growth of species such as pine and sequoia. Natural reproduction of shade-tolerant species such as white fir and incense cedar has also created fuel ladders that could take fire up to the overstory (Figure 1). Under extreme weather conditions a wildfire could result in a stand-replacing event, especially in the planted stands.

Figure 2: White fir infected with dwarf mistletoe in Black Mountain Grove in 2003

Figure 3: Planted Stand created in the 1980s in Black Mountain Grove



Effects Analysis

Direct and Indirect Effects

The FVS modeling focused on the effects of a potential wildfire and fuels reduction activities on the vegetation in the project area. The effects analysis also emphasizes potential impacts on those forest stand characteristics important for old growth wildlife habitat including canopy cover, basal area and snag density (FVS modeling on file at Western Divide Ranger District).

The direct effects of Alternative 1, no action, would be a continued accumulation of surface and ladder fuel in the form of intermediate and suppressed trees, standing snags, and fallen trees and limbs. Without treatment, FVS modeling of the areas with old growth habitat characteristics suggests that stands would exhibit a slight increase in both canopy cover and live tree basal area by the end of the first decade (2020) on approximately 2,149 acres. As shown in Table 4, weighted average canopy cover in 2010 was estimated at 62 percent, increasing to an estimated 65 percent by 2020.

Table 4: FVS Canopy Cover Percentage by Alternative

Alternative 1 (No Action)			Alternative 2		Alternative 3	
Time Frame	No treatment or Wildfire	No treatment with Wildfire	Treatment* with No Wildfire	Treatment with Wildfire	Treatment with No Wildfire	Treatment with Wildfire
2010	62	62	62	62	62	62
2020	65	21	61	34	60	51

*Treatment for action alternatives includes: (thin, pile burn, jackpot pile burn, understory burn, and felling of imminent hazards) in the areas currently considered suitable old forest habitat types (approximately 2,149 acres total).

However, under Alternative 1 the increasing canopy cover, especially in the form of co-dominant, intermediate, and suppressed trees, may have an indirect effect of increasing the amount and susceptibility of larger-sized trees being damaged or killed in a wildfire as they contribute to ladder fuels mainly in the planted stands. As shown in Table 4, a wildfire could greatly reduce the canopy cover across a large portion of the project area. A fire that reduces the canopy cover by almost two thirds could also open up the stands and improve regeneration by shade intolerant species such as pine and sequoia.

There is no timber harvest proposed in this project, instead, both action alternatives propose fuel reduction treatments. The most important of these is treating the surface fuel, but they do include thinning of ladder fuels made up of small trees (i.e. intermediate canopy and suppressed) and brush. The canopy structure varies with age, aspect, elevation, slope position, and growing site quality. Table 4 compares overall canopy cover in the high quality old forest habitat areas before and after treatment.

Implementation of Alternative 2 or 3 is not anticipated to substantially alter the vegetation characteristics that are important for old growth habitat in the project area. Existing canopy cover would slightly decrease in the short term. FVS modeling predicts that the weighted average canopy cover would drop to almost the same percentages post implemenation (2020) under either action alternative. The bulk of overhead canopy formed by dominant and co-dominant trees in the stand would not be altered in the existing old forest habitat types available in the project area. In addition, untreated stands exhibiting dense canopy cover (exceeding 61 percent) would continue to exist randomly across the landscape, and contribute to overall forest heterogeneity.

Under either action alternative not all small trees (12 inches or less) would be felled with fuels reduction work. No sequoias would be felled. Those trees left on site are to have good form and potential for growth, with a focus placed on retaining giant sequoia, pine and black oak, over fir and cedar. Thinning small trees, while leaving large and moderate trees in the overstory, would lead to improved stand health, and a diversity of canopy layers.

Under Alternative 1 weighted average live tree basal area in the areas with old growth habitat characteristics was estimated at approximately 326 sq.ft./acre in 2020 with no treatments or wildfires (Table 5).

Table 5: FVS Basal Area Percentage by Alternative in 2020 with and without a Wildfire

Alternative	No Wildfire in 2020 (percent Basal Area)	Wildfire Occurrence in 2020 (percent Basal Area)
Alternative 1 (No Action)	326	118
Alternative 2 (Proposed Action)	309	185*
Alternative 3	306	279*

*Assumes wildfire occurrence after treatments. Treatment for action alternatives includes: (thin, pile burn, jackpot pile burn, understory burn, and felling of imminent hazards) in the areas currently considered suitable old forest habitat types (up to approximately 2,149 acres total).

In contrast, a FVS modeled wildfire in 2020 under the current stand conditions in Alternative 1 suggests that a substantial decrease in live tree basal area would occur, dropping to an estimated 118 sq. ft./acre (Table 5). Depending on the scale of any one fire event, there is potential that most of the understory basal area would be burned up, and even some of the condominant overstory as well.

Both action alternatives propose retaining the larger trees and thinning the smaller trees in the stands to an average of 70 trees per acre, which is equivalent to 25 foot average spacing. The suppressed understory trees proposed for cutting under this project would have no value for producing lumber. There would be no need to remove merchantable trees to thin smaller trees. It may be possible to use some of the thinned material through the personal use firewood program.

To help reestablish stand resiliency and species composition Alternatives 2 and 3 would retain all trees over 12 inches dbh, and in the following order of preference: giant sequoias, black oak, pines, and an average of the hardwoods on a per acre basis. Both action alternatives would include a mitigation measure to protect giant sequoias from fire by having firefighters pull heavy accumulations of fuel away from large giant sequoia trees before prescribed burning.

In Alternatives 2 and 3 FVS modeling predicted that live tree basal area would decrease in treated locations. Comparisons between 2020 values show that basal area would decrease to similar levels under alternative 2 or 3. However, as shown in Table 5, fuels reduction work accomplished in Alternative 3 is anticipated to allow for greater retention of existing basal area under a wildfire in comparison to the other alternatives. FVS predicts basal area would be retained at 279 sq.ft./acre with Alternative 3, which is about one third more than Alternative 2, and over twice as much basal area retention as Alternative 1.

Under Alternative 1, the number and distribution of medium to large live trees is anticipated to slowly increase over the next 50 years. FVS values noted in 2010 were estimated at 19 trees per acre, increasing to approximately 21 trees per acre given normal growth at current stocking levels by 2020. Under No Action with a modeled wildfire (2020), the trend line is similar to that of No Action without wildfire but then strongly increases starting in 2040. This increase represents growth of remnant trees not consumed by the fire, given decreased competition and lower overall stand density.

The direct effects of Alternative 2 on 1,410 acres, or Alternative 3 on 2,830 acres of the project area would be a decrease in surface and ladder fuel. By felling the suppressed understory trees, this project would temporarily raise the average diameter of trees (Oliver et al. 1996). This effect will disappear in the first decade after treatment because prescribed burning will stimulate a flush of shade tolerant regeneration. The primary treatment will be reducing the amount of surface fuel. The action alternatives would also result in reductions in the canopy, mainly at the lower heights, and exposure of mineral soil.

Under Alternatives 2 or 3, FVS predicts that the number of medium to large live trees and their distribution to remain at relatively the same trajectory as that of Alternative 1 over the first several decades, since large live trees would not be felled. Thinning guidelines for this project also favor the retention of shade intolerant tree species including sequoia and pine and black oak when present. Only small trees (12 inch dbh or less) would be thinned to reduce ladder fuels. After thinning, mix of this size class will be retained throughout the understory and in the planted stands.

Snag levels for larg snags are not predicted to change substantially based on FVS modeling. However, the type of snag is likely to change. Under Alternative 1, the number of snags in all size classes would continue, with the majority of snags in the intermediate and suppressed canopy. No treatments in Alternative 1 may result in recruitment of larger material as mortality occurs due to overstocked stand conditions, and drought induced stress.

In the short term, large snag density is anticipated to slightly increase in Alternative 2 and 3, due to project induced tree mortality (Table 6). In both action alternatives snags would be felled if deemed an imminent safety hazard, but otherwise would be retained. The majority of snags within the project area would be left, maintaining these desirable attributes across the landscape.

Table 6: Average Tree Mortality from Prescribed Burning by Size Class

Mortality (Trees per acre) *	Alt 1	Alt 2	Alt 3
Trees < 15 inches dbh (75 percent of these are seedlings)	none	26	26
Trees 15-17.9 inches dbh	none	2	2
Trees 18-23.9 inches dbh	none	1	1
Trees 24-29.9 inches dbh	none	<1	<1
Trees 30-34.9 inches dbh	none	<1	<1
Trees ≥ 35 inches dbh	none	<1	<1

*Mortality is based on the modeled intensity of pile burning and prescribed fire.

To more clearly display any differences between the alternatives, the planted stands were modeled separately, and with and without a wildfire. The modeling projects that the proposed treatment of planted stands would increase the proportion of sequoias in these stand by thinning more trees of other species.

As discussed earlier, both action alternatives propose retaining giant sequoia, black oak, pine, and other hardwoods that have good form and potential for growth. Focusing retention on the more shade intolerant species, particularly sequoias, may alter the species composition and make the planted stands more resilient to predicted changes in climate. Thinning small trees, while leaving the larger-sized trees, would lead to improved stand health and a diversity of canopy layers in these planted stands. In those planted stands where more small trees are present, thinning could lead to accelerated growth, and vigor while reducing inter-tree competition. Reducing surface fuels and the densities of small-diameter stems may be the best means of creating more resilient forests (North et al. 2009, p. vi). Over time this would increase the recruitment and development of larger trees over 12 inches dbh as the planted stands mature.

Cumulative Effects

Most past actions within this analysis area have occurred long ago and are considered part of the affected environment for most resources. One project that was recently completed is the Camp Nelson Project. The Camp Nelson Project reduced surface and ladder fuels by thinning trees up to 10 inches dbh, and contributes towards management desired conditions. There are no other reasonably foreseeable projects currently proposed that may affect vegetation in the TRRP Project at this time.

In the event of a wildfire under Alternative 1, the cumulative effects on tree mortality and reductions in canopy cover could be greatly increased, due to buildup of surface and ladder fuels over the past several decades. In contrast, in the event of a wildfire after implementing Alternatives 2 or 3 the cumulative effects on tree mortality and reduction in canopy cover would be minimized due to reduction in surface and ladder fuels in the project area, particularly the Black Mountain Grove.

In the long term, implementation of either action alternative, especially if a wildfire occurs, may result in increased acres of CWHR size 4 and 5 habitat types (Parisi et al 2007), and increased opportunities for successful natural regeneration of trees (Beetham 1962, Hartesveldt et al. 1975). However, Alternative 1 could lead to the greatest increase in natural regeneration as a result of a stand-replacing wildfire, due to the modeled decreases in stand density.

Base on the direct and indirect effects of implementing Alternatives 2 or 3, a wildfire occurring in the project area is more likely to be a low-severity fire (Hurteau et al. 2009, Stephens et al. 2009b). The cumulative effect of the fuels reduction treatments would produce a forest structure in the mixed-conifer stands that is more resilient to insect and pathogen mortality at low, chronic levels (North et al. 2009).

Mitigation

For alternatives 2 and 3, pull heavy accumulations of fuel away from large giant sequoias to prevent mortality during prescribed burning.

Literature Cited

Beetham, Nellie May. 1962. The Ecological Tolerance Range of the Seedling Stage of Sequoia gigantea. Duke University, Durham, NC.

Dixon, G.E. 2010. Essential FVS: A User's Guide to the Forest Vegetation Simulator. Forest Management Service Center, Fort Collins, CO.

Hartesveldt, R. J., H.T. Harvey, H.S. Shellhammer, and R.E. Stecker. 1975. The giant sequoia of the Sierra Nevada. Department of the Interior National Park Service. Washington, D.C.

Henderson, Jan A. et al. 2011. A landscape model for Predicting Potential Natural Vegetation of the Olympic Peninsula USA using Boundary Equations and Newly Developed Environmental Variables, USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Jump, L. H. 2004. Black Mountain Giant Sequoia Grove Inventory: Sequoia National Forest. Porterville, CA.

Mayer, K.E., and W.F. Laudenslayer, eds. 1988. A Guide to Wildlife Habitats of California. California Department of Forestry and Fire Protection, Sacramento, CA.

Meyer, Frederick and Dean Schlobohm (alternate author name California State Park Commission) 1952. Status of Sequoia Gigantea in the Sierra Nevada. Report of the State Park Commission and the State Forester to the State Legislature.

Meyer, M. and Stafford, H. 2011. Giant Sequoia Regeneration in Groves Exposed to Wildfire and Retention Harvest. Fire Ecology, Volume 7, Issue 2: pp. 2-16.

North, M., et al. 2009. An ecosystem management strategy for Sierran mixed conifer forests. USDA Forest Service, Pacific Southwest Research Station. Albany, CA.

Oliver, W. W., Farrell, G.T. and Tappeiner, J. C. 1996. Density management of Sierra Nevada forests, in Sierra Nevada Ecosystem Project Final Report to Congress, Volume III, Assessments, Commissioned Reports, and Background Information, pages 491-500. Davis, CA.

Parisi, M.D., Motrini, R.S., and Robards, T.A. 2007. Clarification of the Measurement of California Wildlife Habitat Relationships (CWHR) System Size class 5 and 6 for Tree Habitats. Sacramento, CA. http://www.dfg.ca.gov/biogeodata/cwhr/pdfs/CWHR_TechReport32.pdf

Sherlock, J.W. 2007. Integrating stand density management with fuel reduction. In Powers, Robert F. ed. Restoring fire-adapted ecosystems: proceedings of the 2005 national silviculture workshop PSW-GTR-203.USDA Forest Service, Pacific Southwest Research Station. Albany, CA: 55-56.

USDA Forest Service, 1991. Forest Service Manual 5150 Fuel Management. Washington, D.C.

USDA Forest Service. 2013. Common Stand User's Guide. http://www.fs.fed.us/nrm/documents/fsveg/cse_user_guides/Cover_userguide.pdf

USDA Forest Service. 2012. Giant Sequoia National Monument Management Plan. Sequoia National Forest. Porterville, CA.

USDA Forest Service, 2013. Forest Service Manual 2020 Ecological Restoration and Resilience. Washington, D.C.